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Research Article

The Design of Automatic Stirring Ripe Tea Fermenter for Puer Tea

Wu Xiaoqiang
College of Mechanical Engineering, Inner Mongolia University for the Nationalities, Tongliao, Inner Mongolia 028000, China

Abstract: Traditional ripe tea fermentation is directly stacking puer tea material on the ground of fermentation workshop relying on natural environment to ferment. The way of fermentation, which has poor degree of sanitation, makes fermentation process influenced by environmental change and difficult to ensure product quality and stability. To solve this problem, we design a ripe tea fermenter for puer tea. There is a certain distance between fermenter and the ground and the spindle of fermenter is designed, so as to achieve automatically agitation instead of manually turning process. It can monitor and control temperature and humidity of tea in the fermenter, so that in the fermentation process puer tea will be in a stable environment, improving fermentation process and the quality of temperature fermentation.

Keywords: Fermenter, tea fermentation, temperature and humidity regulation

INTRODUCTION

Raw material of puer tea is a large leaf variety of Yunnan drying green tea. Produced through the specific process, puer tea, which has unique quality characteristics, is unique geographical indication products in Yunnan (Zhou *et al*., 2002; Luo and Shao, 2006; Shi, 1997). Since 2007, industry of Yunnan tea which is mainly puer tea has entered a historical period of rapid development. The province's tea planting area reached 400 acres; production reached 178,000 tons; the tea industry output value reached 20.1 billion Yuan. For tea processing technology, the current domestic tea processing still remains in the traditional processing model and workshops account for a large proportion. A certain scale of manufacturing enterprises only have simple processing equipment and production technology workers basically inherit the empirical-formula processing method with intensive labor, so tea fermentation process and quality is affected by change of environment significantly (Li, 2002). In order to overcome the labor-intensive and the problem that fermentation is affected by the environment, in this study a tea fermenteris designed. In the design process we first use Pro/e for 3D modeling and ANSYS to make the finite element analysis, researching the intervention and stress of fermenter. With comprehensive use of PLC, sensors and variable frequency technology, we make acquisition, storage, processing and corresponding automatic control for the data related to quality formation in the tea fermentation process. The ultimate goal of design is to give an economic, reasonable and reliable design description, which makes strength reliable and functions of control system reasonable when the fermenter operates (Sun *et al*., 2002; Zhou, 2007; Wang *et al*., 1994; Liang, 2004).

THE THREE-DIMENSIONAL MODELING OF FERMENTER BASED ON PRO/E

Materials: M Fermenter mainly consists of five parts: tank, mixing body, the bracket body, chain drive device and motor. The major component models of fermenter are listed in the study below:

- Tank is the main component to store tea and take effect of clean, hydrating, thermal insulation for tea. Figure 1 shows the three-dimensional solid model of fermenter. During three-dimensional modeling a series of commands such as tensile, rotation, removing materials and array are used to make tank model.
- The stirring inlet mechanism is to achieve uniform stirring of tea and the tide effect at the same time, basically to achieve uniform mixing and tide. A number of small holes are opened in the cylindrical surface of the stirring bar, so through spindle the water flow along stirring bar into the interior of fermenter. Based on previous experimental experience, for the arrangement of stirring bars in this study every two stirring bars are arranged along the major axis in a direction of circumferentially rotating 60°, which helps to more uniform tide. Meanwhile, the length of stirring bar is also shortened at the basis of previous experiments. It can be seen in previous experiments, stirring resistance is very large if

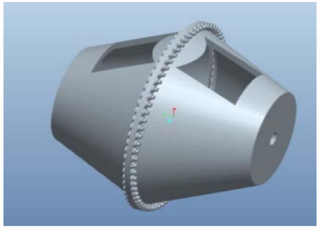

Fig. 1: Model fermenter

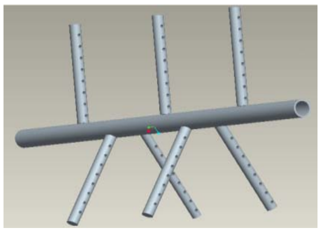

Fig. 2: Stir spindle model

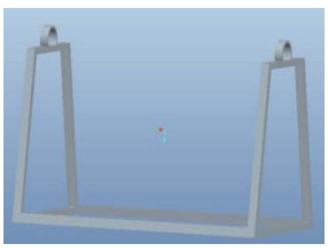

Fig. 3: Support model

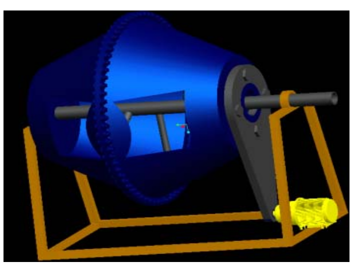

Fig. 4: Fermenter overall model

stirring bar is too long. So shortening the stirring bar helps to reduce the stirring resistance. Figure 2 shows the three-dimensional solid model of the inlet, stirring mechanism inside fermentation.

- In the entire mechanism bracket takes an effect of supporting the tank and tea inside it, to ensure that tank has no contact with ground during rotation. Figure 3 shows the three-dimensional solid model of the entire bracket of fermenter.
- Various components are assembled one by one. In the study a virtual prototype model of fomenters established in Pro/E environment, shown in Fig. 4. The establishment of model has prepared for subsequent simulation work and the production of prototype.

FINITE ELEMENT ANALYSIS OF FERMENTER

A When carrying out the overall design of the fermenter, the strength analysis of various components is required. Since the work device is a spatial statically indeterminate system with relatively complex force, strength calculation using traditional planar analytic method, not only need a heavy workload, but also cannot get completely accurate and reasonable selection of the dangerous section. Therefore the results may not be scientific. In this study, finite element analysis with ANSYS can accurately reflect force situation of components.

Problem description: Force situation fermenter spindle can be seen as concentrated forceacting on the center of a thin-walled cylinder, as shown. Spindle material is 302 stainless steel which meets the requirements of food safety and hygiene. Elastic modulus E = 193GPa; Poisson's ratio v = 1.5; concentrated force F = 3000N.

Analysis of the problem: Fermenter spindle force belongs to structural analysis problems of thin-walled workpiece. According to the symmetry, 1/8 of cylinder is selected to establish geometry model; the corresponding load is quarter of the original load. So SHELL150 shell element is chosen to make the analysis.

Generating the geometric model and meshing: Bottom-up and top-down modeling are two methods of solid modeling. The so-called bottom-up modeling means the key points is first defined and then with the use of key points more advanced entity primitives are defined; top-down modeling means body element is first generated and the lower level of primitives belonging to body element will be automatically generated by ANSYS. In the process of the entity modeling, two kinds of modeling techniques can be freely combined.

ANSYS mathematically expresses geometry of the structure with grid, in which nodes and elements are filled. Load is also easily applied on the geometric boundaries, but the solid model does not refer to geometry finite element analysis. All the loads or constraints applied on the finite element boundary must ultimately be transferred to the finite element model (nodes and elements) to solve it. Mesh achieves the transformation from the solid model to finite element model. Meshing of solid model can be divided in to three different forms, such as free meshing, mapped meshing and swept generation body meshing. Free meshing is used in this study:

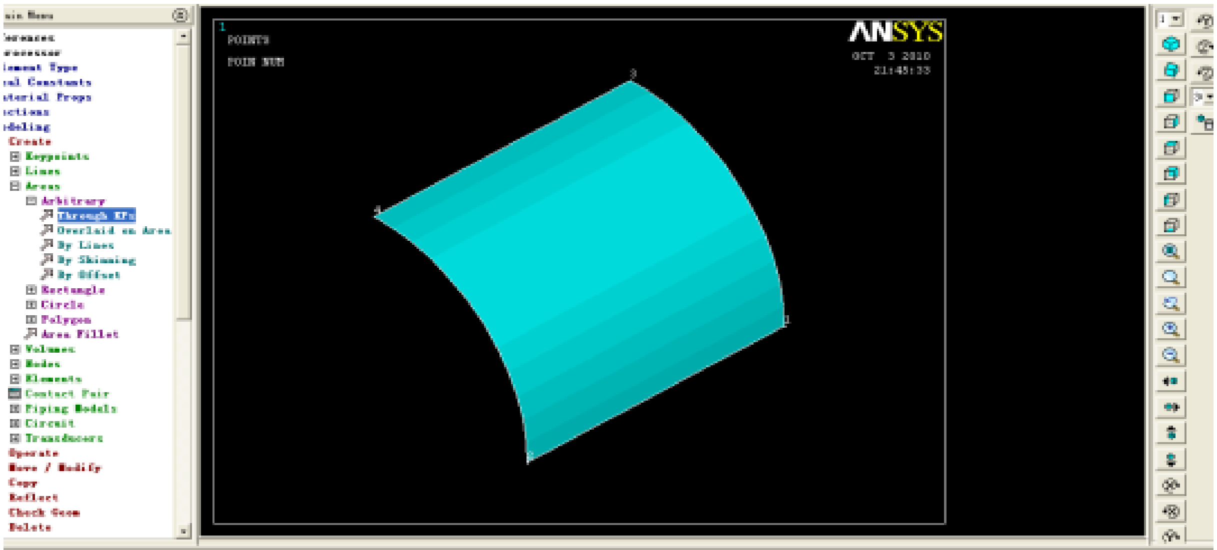

Fig. 5: Generate the geometric model

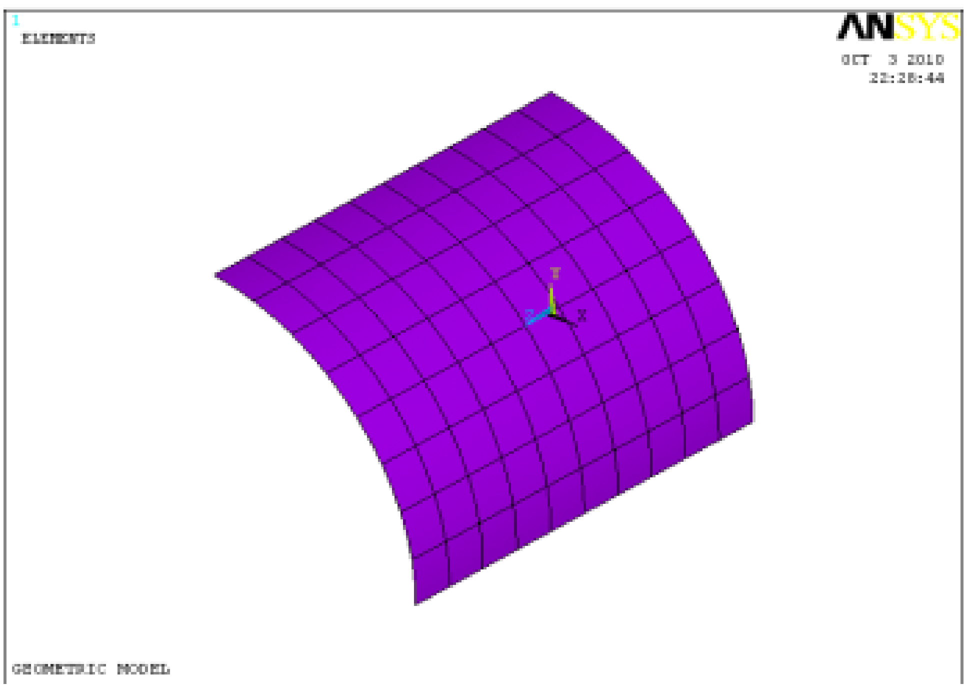

Fig. 6: Meshing results

- Select Global Cylindrical command, the current coordinate system into a cylindrical coordinate system.
- Select Main Menu→Preprocessor→Modeling→ Create→Keypoints→In Active CS command, set the Create Keypoints number that appears.
- Select Mainenu→Preprocessor→Modeling→
- Create→Areas→Arbitrary→Through Kpscommand, In the Create Area thru pickup key point, geometric model generation, as shown in Fig. 5:
- Select Main menu→Preprocessor→Meshing →Mesh→Areas→Freecommand, Free mesh, as shown in Fig. 6:

Load solving:

- Select the Main menu→Solution→Analysis Type→New Analysis command appears New Analysis dialog box, select the type of analysis Static.
- The displacement constraints in Main Menu →Solution Define Loads→Apply→Structural→

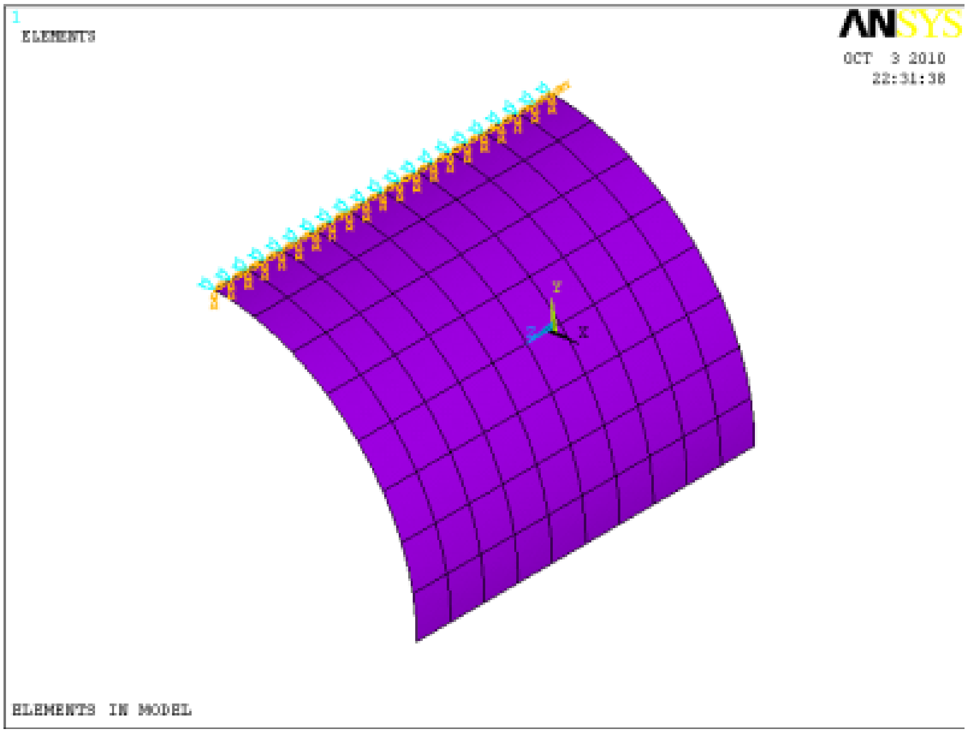

Fig. 7: The results after applying constraints

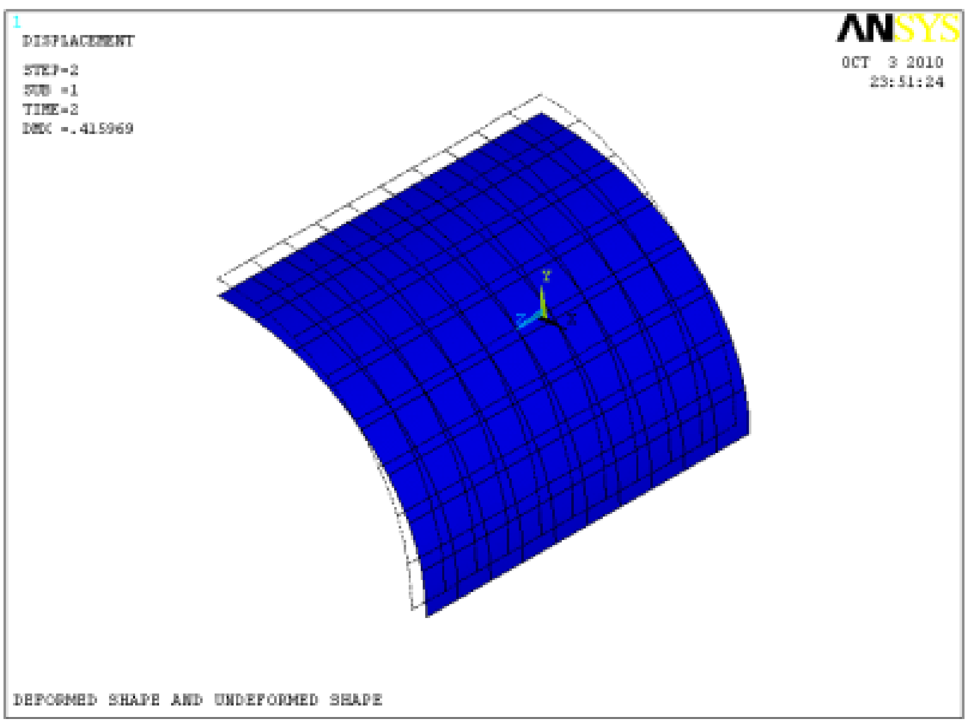

Fig. 8: Geometry of the front and rear deformation

Displacement→Symmetry, B.C→ Node command, as shown in Fig. 7.

- Main Menu→General Postproc→Plot Results→ Deformed Shape command, in Plot Deformed Shape dialog box, choose Def+undef ormed, shows the deformed and undeformed geometry, as shown in Fig. 8.
- Main Menu→General postproc→Plot Result→ Contour Plot→Nodal Solu command in the Item, Comp, Item to DOF solution Translation UX

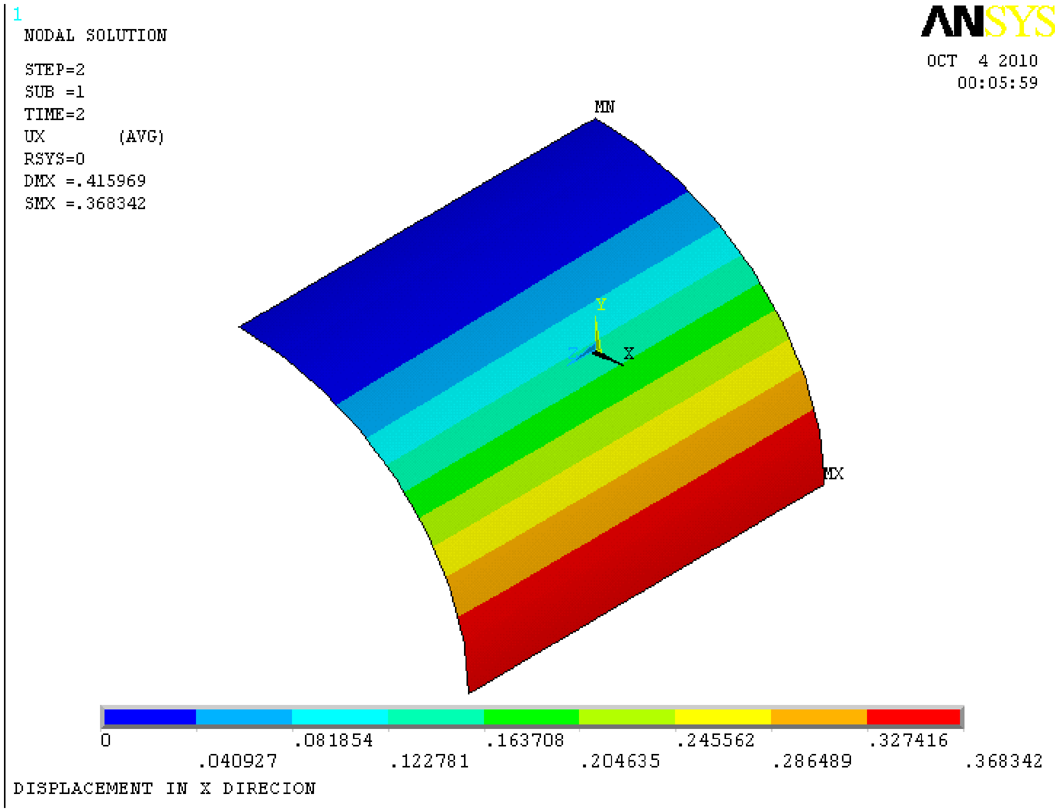

Fig. 9: X direction displacement contour map

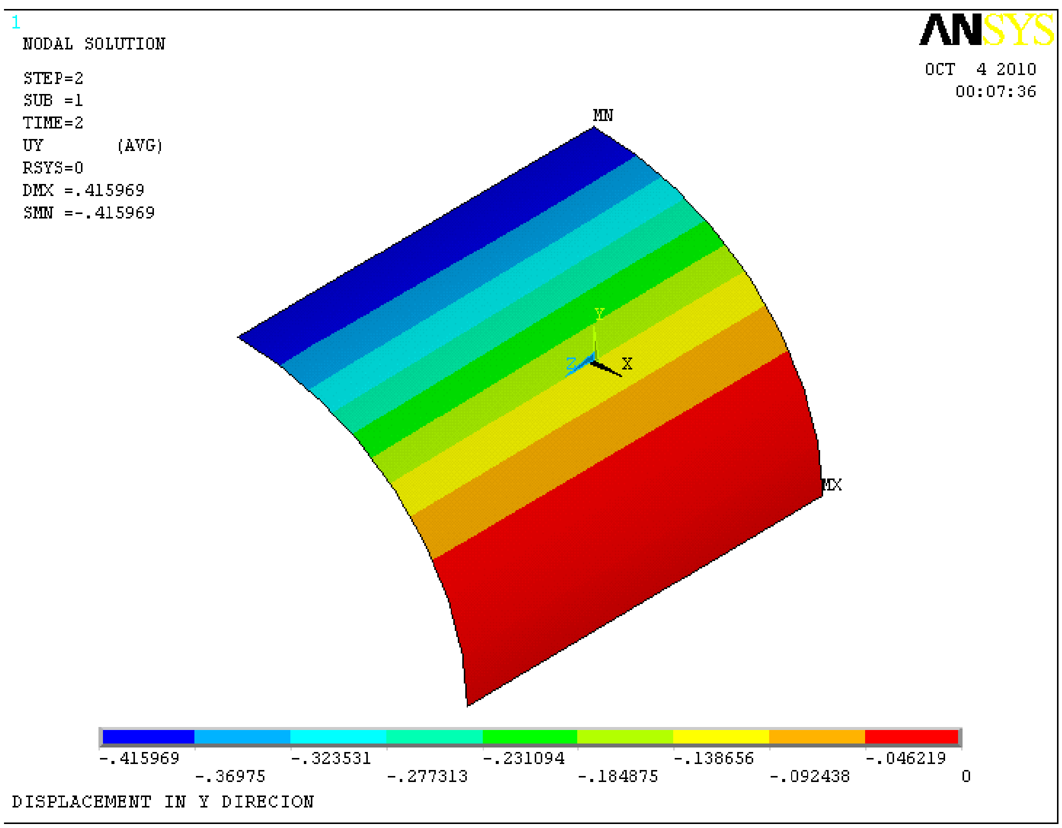

Fig. 10: Y direction displacement contour map

be contoured options, X direction displacement isoline map, as shown in Fig. 9.

- Main Menu→General postproc→Plot Result→ Contour Plot→Nodal Solu command in the Item, Comp, Item to DOF solution Translation UY be contoured options, Y direction displacement isoline map, as shown in Fig. 10.

The maximum stress of spindle can be obtained through analysis, part of the shaft force distribution is substantially uniform and there is the maximum force in the center of the spindle, where dangerous section of the spindleis. The stress here is far less than the strength of the material.

During the analysis, the setting status of each step will have a direct impact on the analysis result, such as dense mesh division, constraints selection, application of load etc. The different results will be obtained through several analysis, because every time the accuracy of the computer is different. But the results of the analysis are similar, the deformation and force distribution of the whole spindle can be seen generally. Therefore, using the finite element method to make force analysis simulation can effectively reflect the variation of spindle force.

CONCLUSION

In this study according to existing questions of ripe tea fermentation, we design a ripe puer tea fermenter to achieve automation of fermentation production. This fermenter designed in this study can reduce labor intensity, stabilize fermentation environment of ripe puer tea, shorten the fermentation cycle and improve economic efficiency for manufacturers, providing a reference for production automation of puer tea fermentation.

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